

Ballistic Missile Defense Technology Overview For The 7th Annual AIAA Technology Readiness Conference

Cleared For Open Publication, Directorate
For Freedom Of Information And Security
Review, Department Of Defense



3 AUG 98

**Dr. Bruce Pierce
Deputy For Technology
Ballistic Missile Defense Organization**

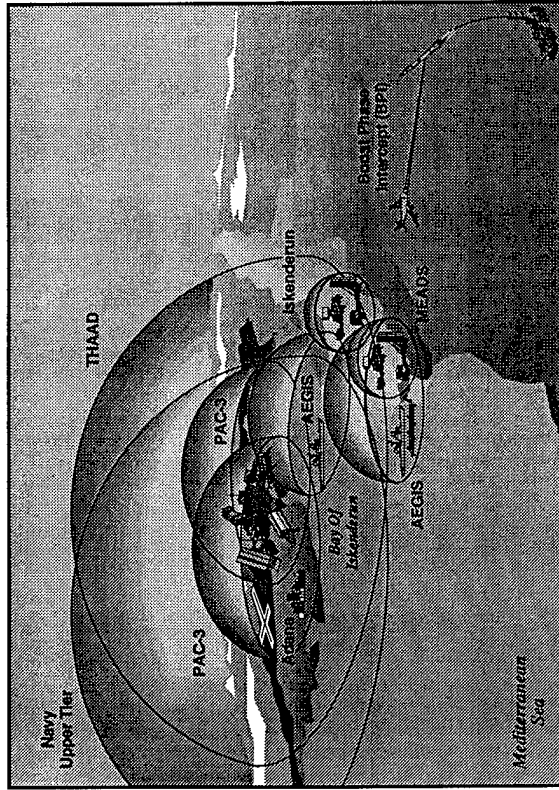
DTIC QUALITY INSPECTED 4

19981110 082

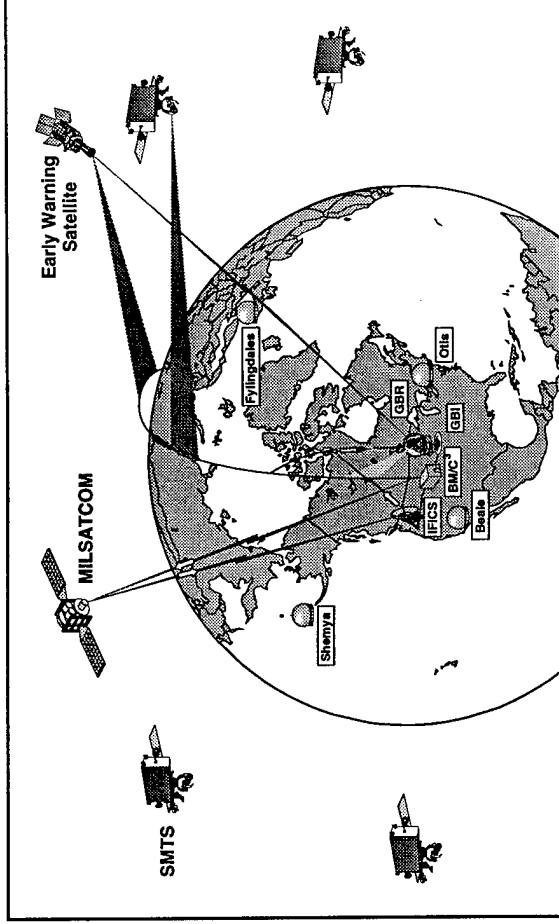


BMDO MISSIONS

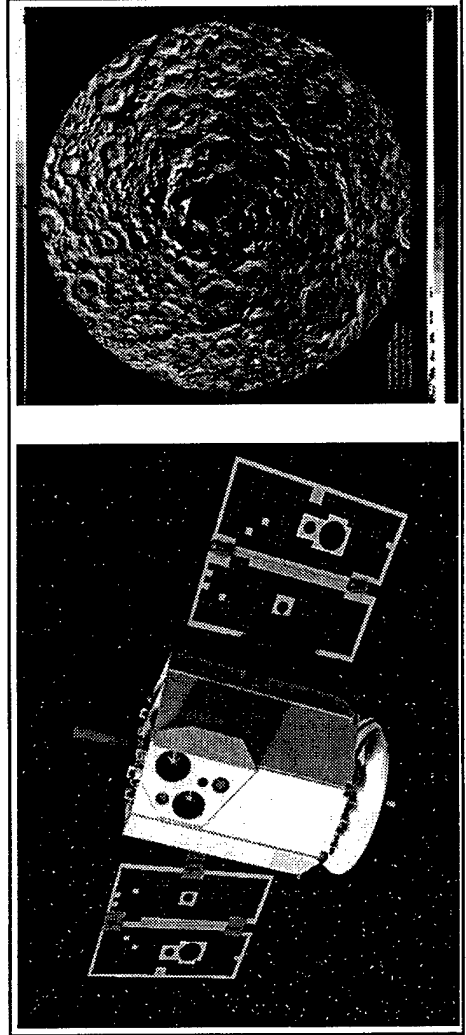
TMD • Acquisition



NMD • Deployment Readiness Program



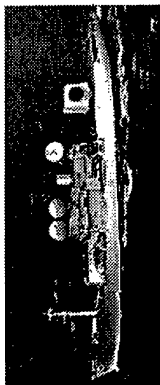
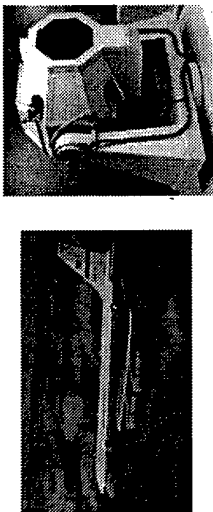
Technology • Component And Advanced Concepts R&D



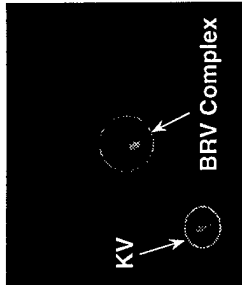


TECHNOLOGY SUPPORT OF TMD AND NMD ACQUISITION PROGRAMS

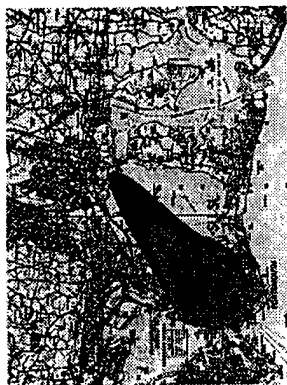
Data Collection And Analysis



Test Assets



Target Signatures



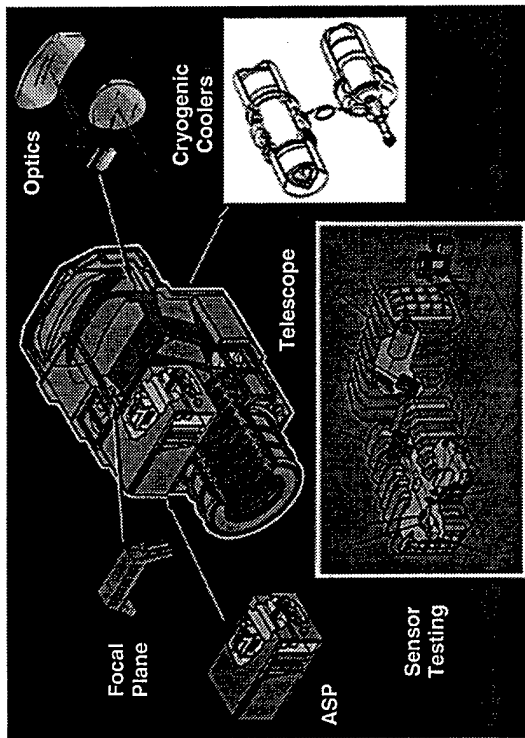
Warhead Fallout



Target Destruction

Lethality

Sensors



SMTS, GBI Components

Advanced Interceptor Technology

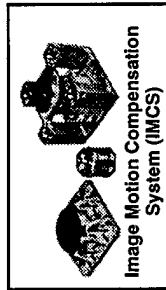
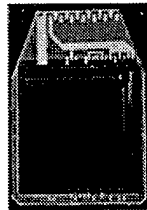


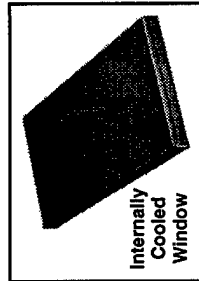
Image Motion Compensation System (IMCS)



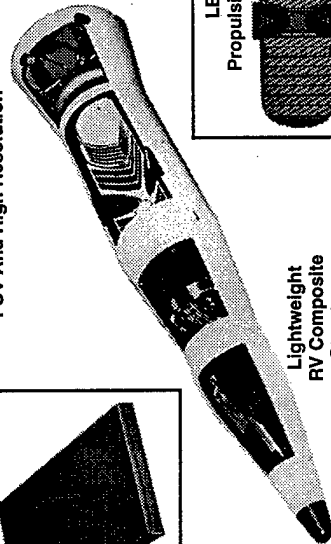
Dual FPAs For Wide FOV And High Resolution



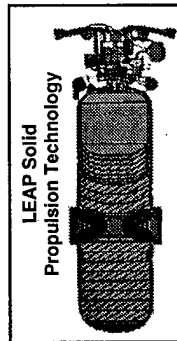
Rapid Cooldown Cryogenics



Internally Cooled Window



Lightweight RV Composite Structure



LEAP Solid Propulsion Technology

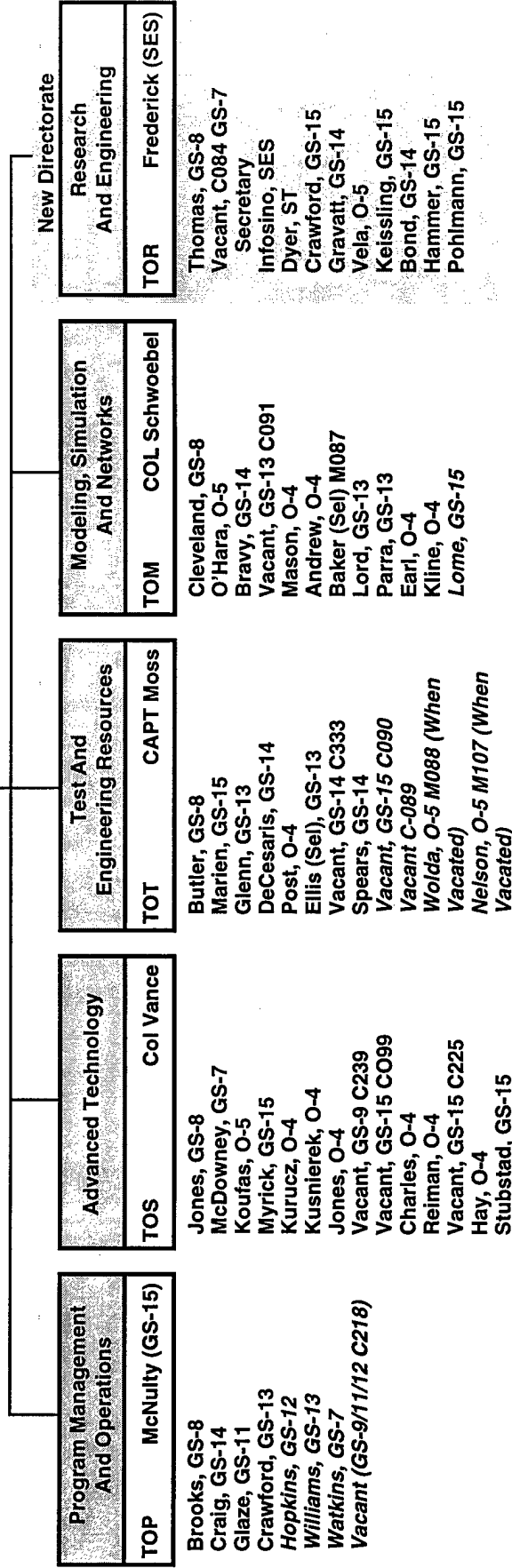


DEPUTY FOR TECHNOLOGY

| TO Deputy For Technology | |
|--------------------------|------------------------------|
| Deputy Assistant Deputy | Pierce (SES) Duston (SES) |

Executive Officer
MAJ Earl (Matrix)
Secretary
Ford, GS-9
Secretary
Green, GS-8
Administrative NCO
Baker E-5

Program Analyst
Ruemmele, GS-15



Staffing: 74

Names In Red / Italics Reflect Personnel Realignments / Reassignments



BMDO CORE GROUND TEST FACILITIES

| Core Ground Test Facilities |
|--|
| <ul style="list-style-type: none"> • Approved By T&EWG(R) • Endorsed By SEAB |
| ACSC-CSEDS ARC / SED-GBRTB-TRTB AEDC APTU AEDC 7V / 10V Space Chambers AOEC AEDC Range G AEDC Hypervelocity Wind Tunnel 9 AEDC VKF AMCOM IIRSS AMCOM MSS-2 CISF-EUWR HHSTT ARC / ISTC JHU / APL GSEL JHU / APL Wind Tunnel JNTF / CERES-BESC-TMDSE JTDL KHILS NHTF NIST LBIR Calibration Facility POST SED / TMTD-FMS |

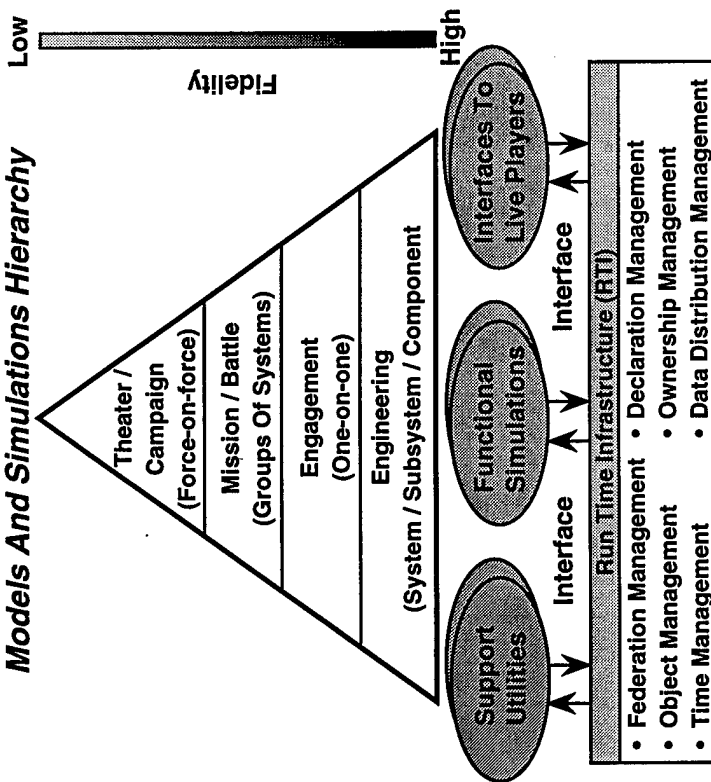
| Facilities Considered But Not Designated As Core |
|--|
| AC SIS AMOR CCC GTSF LMMC SIL LVHWIL MFSIM NRaD PAC-3 SIM PATSIM SMCo HWIL UAH / HBRF |

Note: Facilities Presented To The SAEB As The Minimum Necessary To Preserve Core Infrastructure In Support Of Multiple Programs – *Not Prioritized*

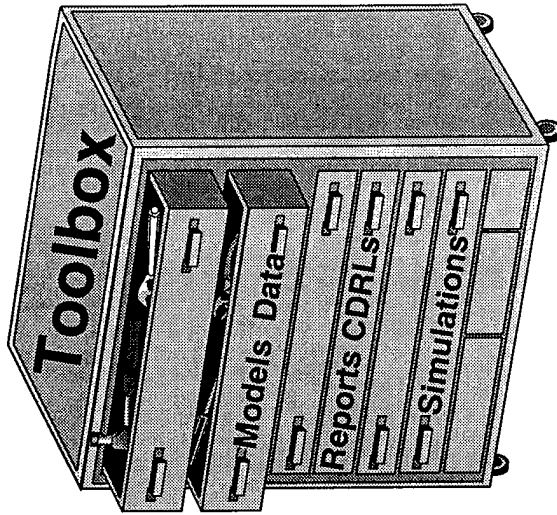


CONCEPT DEFINITION SUPPORTS OVERALL M&S VISION

Models And Simulations Hierarchy



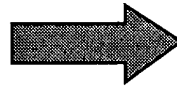
The Question ?



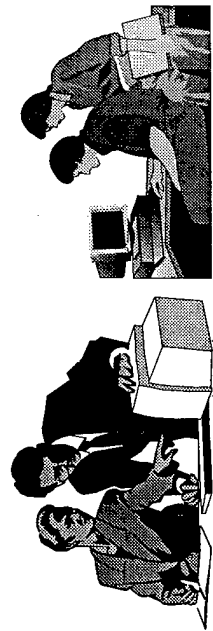
Customers
(e.g., Analysts,
Program Managers,
Contractors, etc.)



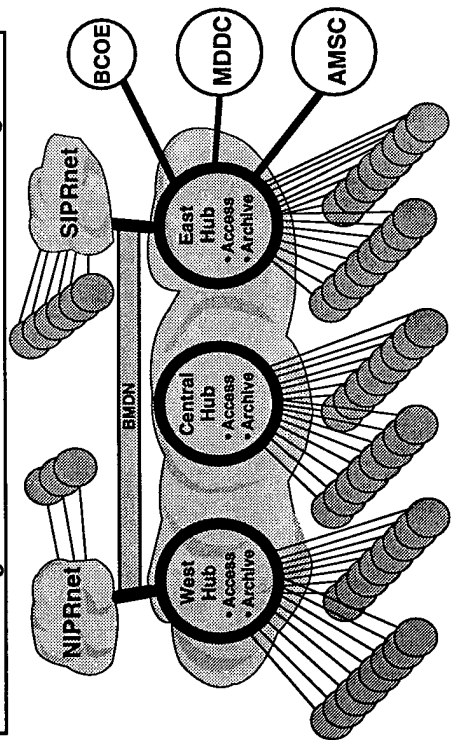
Location X



Location Y



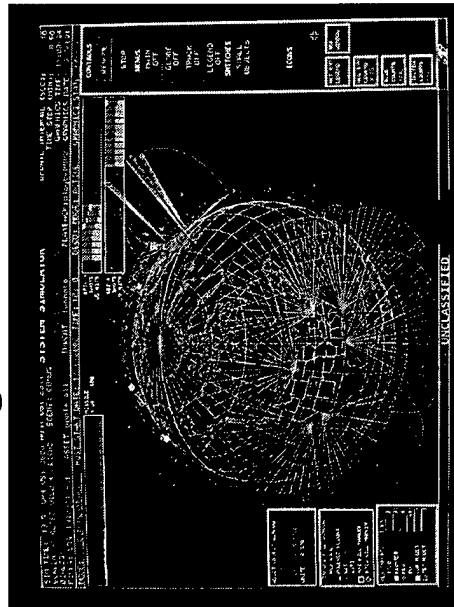
The Answer !



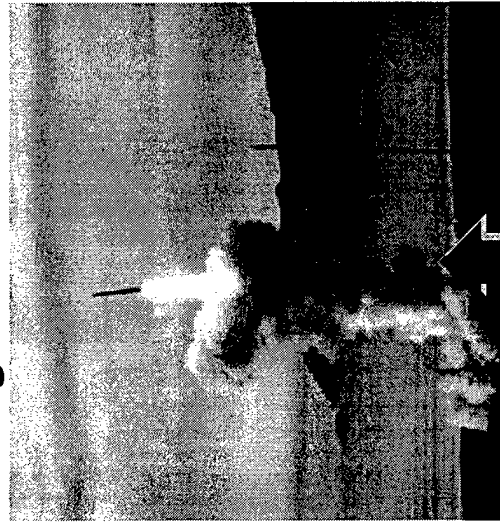


JNTF SUPPORT TO ACQUISITION AND WARFIGHTERS

Modeling And Simulation



Testing And Evaluation



War Games And Exercises



**Acquisition
Decisions**

Analysis

Basis For Operational Capability

**Warfighter
Decisions**





THREAT EMULATION

Defined Threat Choices



No Dong



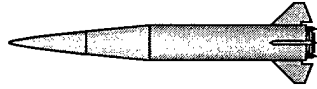
Scud B



Scud C



Scud B
MOD 2



M-9

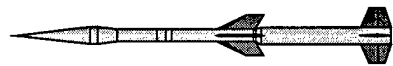


B-610



SS-21

Realistic Targets Competitive Sources



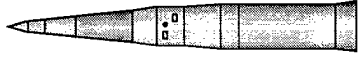
Terrier-
Orion



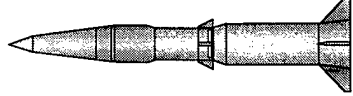
Lance



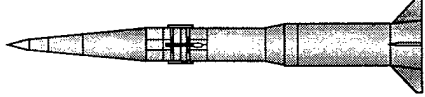
Hermes



AKAir
Storm II
Hera A



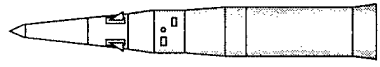
2-Stage
Hera
(Unitary)



2-Stage
Hera



Long-range
Air Launch
Target

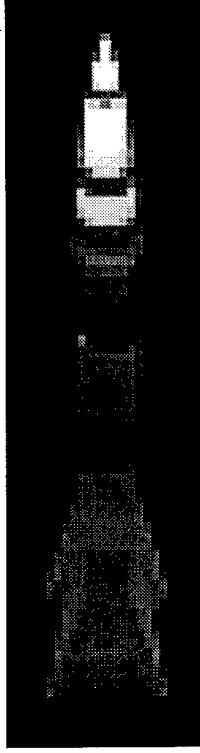
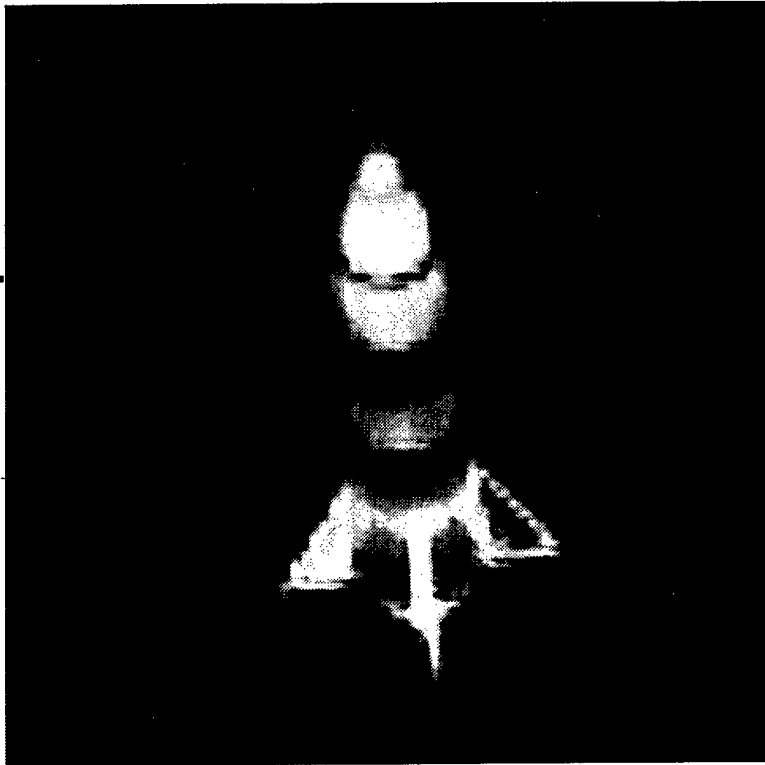


Storm II

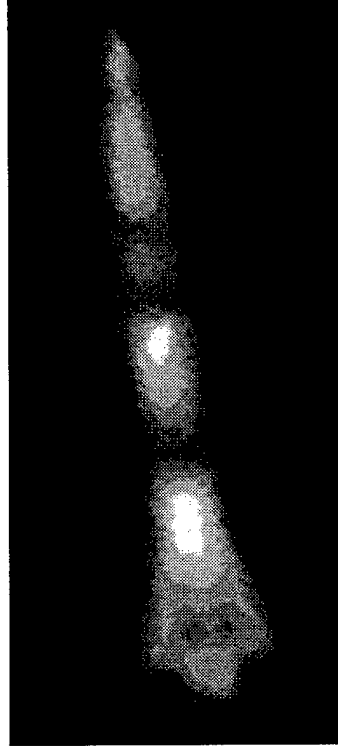


TMD TARGET SIGNATURES LANCE MISSILE

**SM-2 Block IVA IR Seeker
24 JAN 97 Intercept Event**



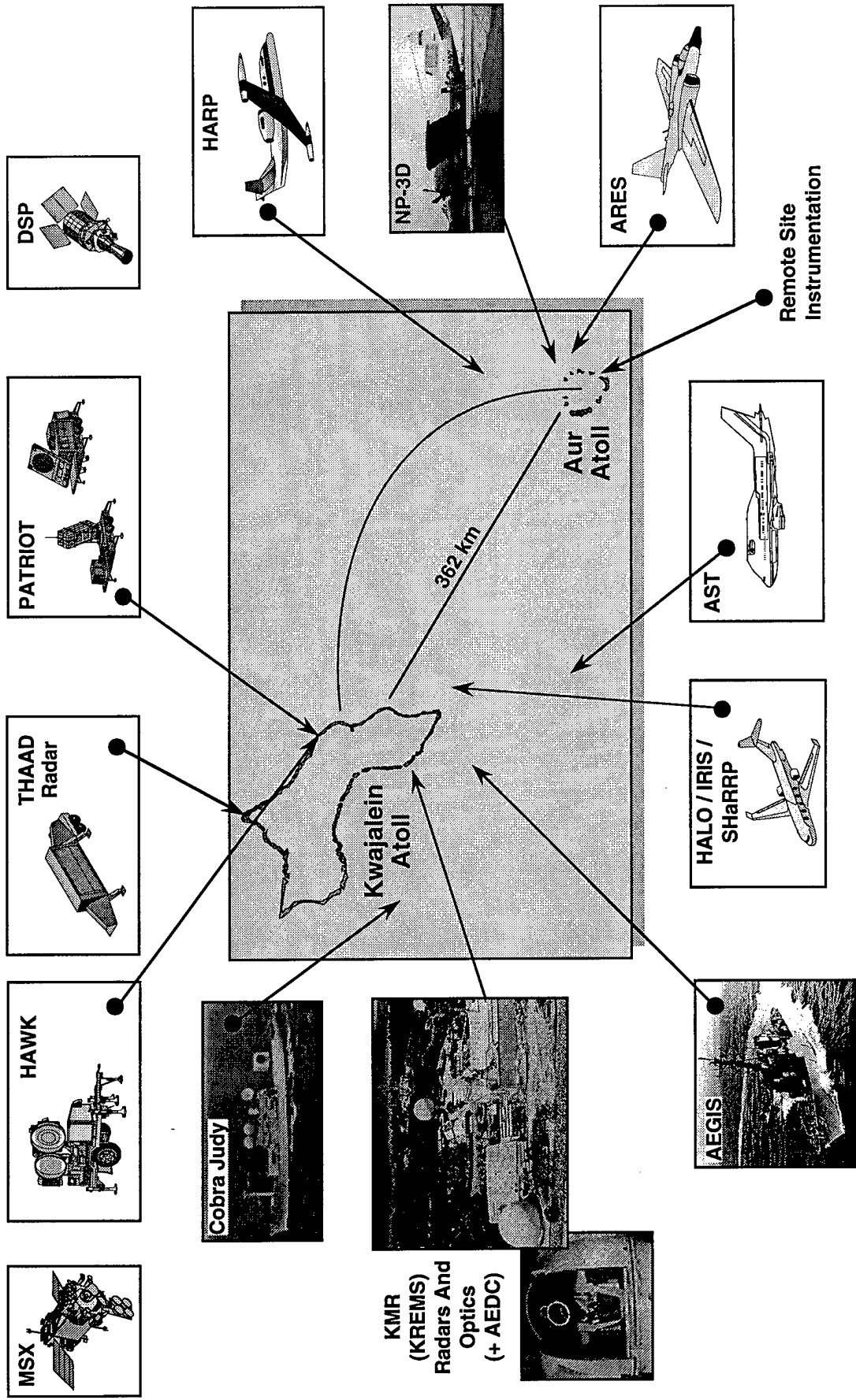
Calculated IR Image



**Sea Light Beam Director
IR Image (1993)**



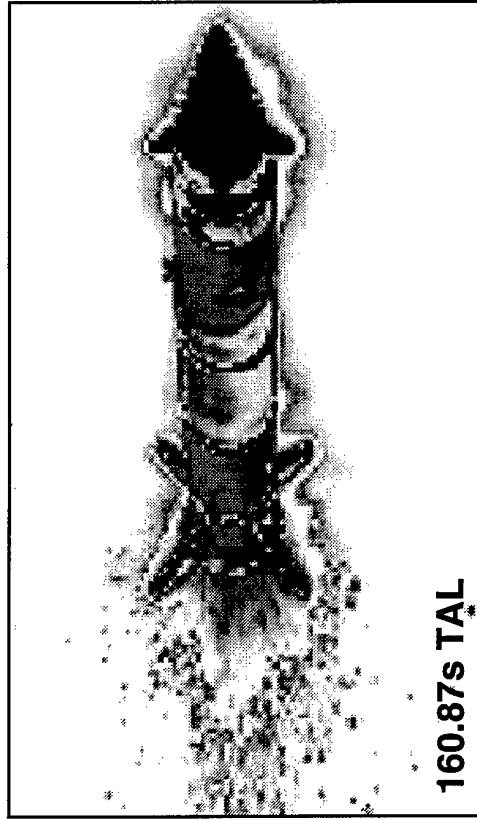
WILLOW DUNE FEBRUARY 1997



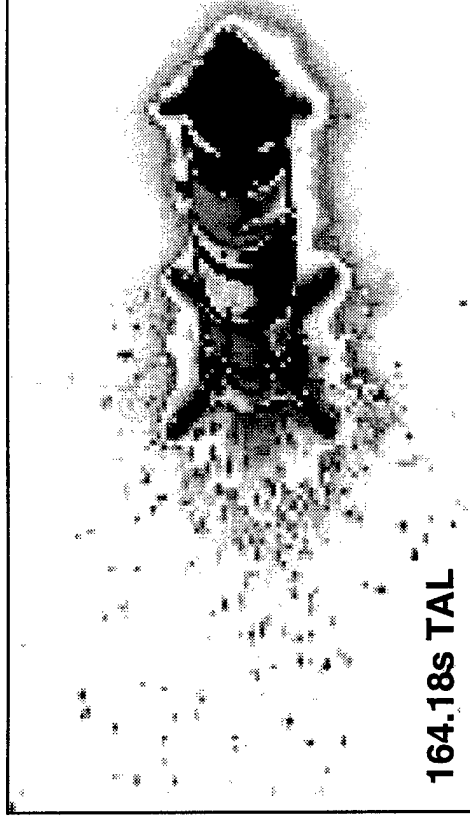


SOLID FUEL DEBRIS

FASP IR IMAGES



160.87s TAL

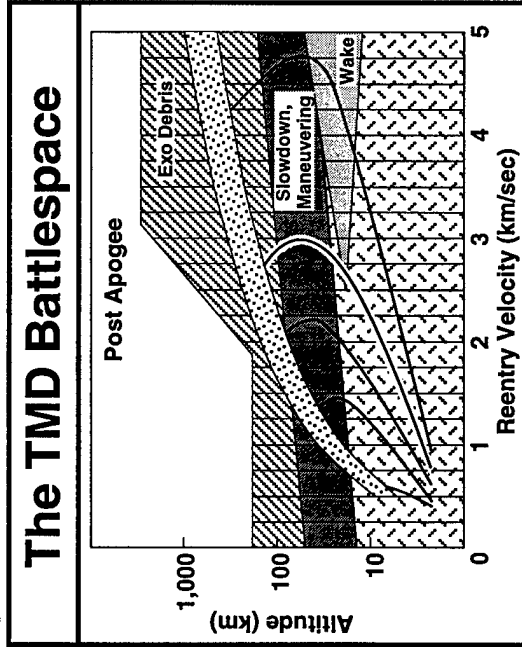
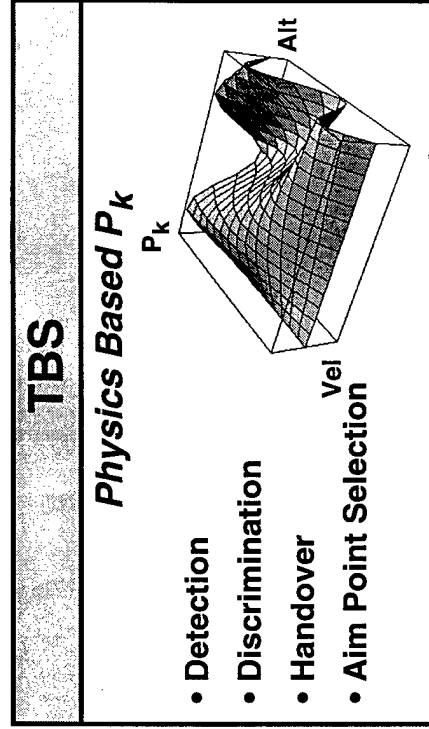
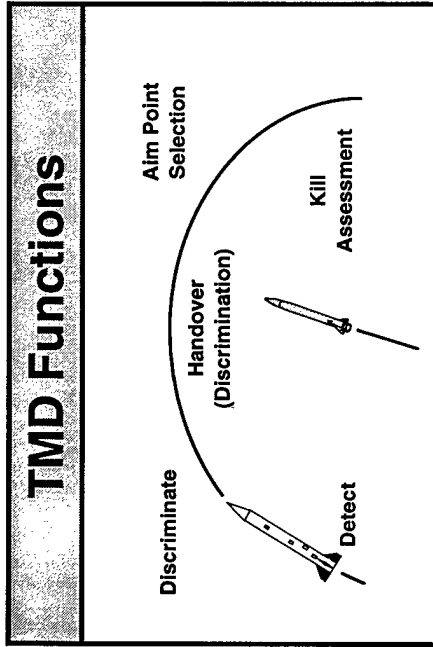


164.18s TAL

**Bright Solid Rocket Fuel Debris Appeared During Entire
TCMP-2B Flight (Images ~100 Seconds After Burnout)**



THE TMD BATTLESPACE STUDY (TBS)



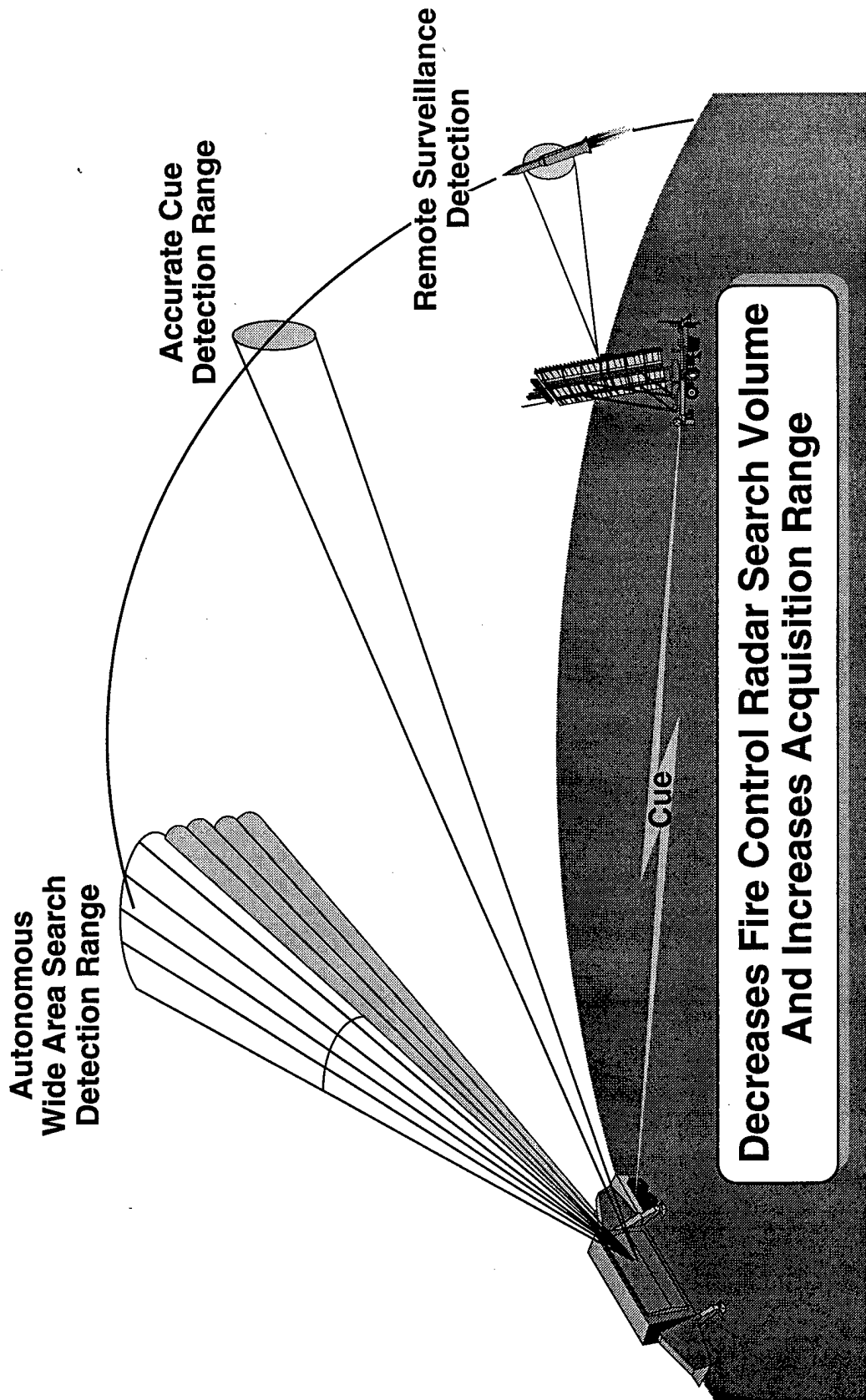
Ascent Phase (NTW)

TBS Goals

- *Preserve System Performance By Establishing The Factors Which Determine P_k*
- *Support Engagement Strategies Based On Best P_k Available In The Battlespace - Family Of Systems Perspective*
- *Support Funding Decisions*

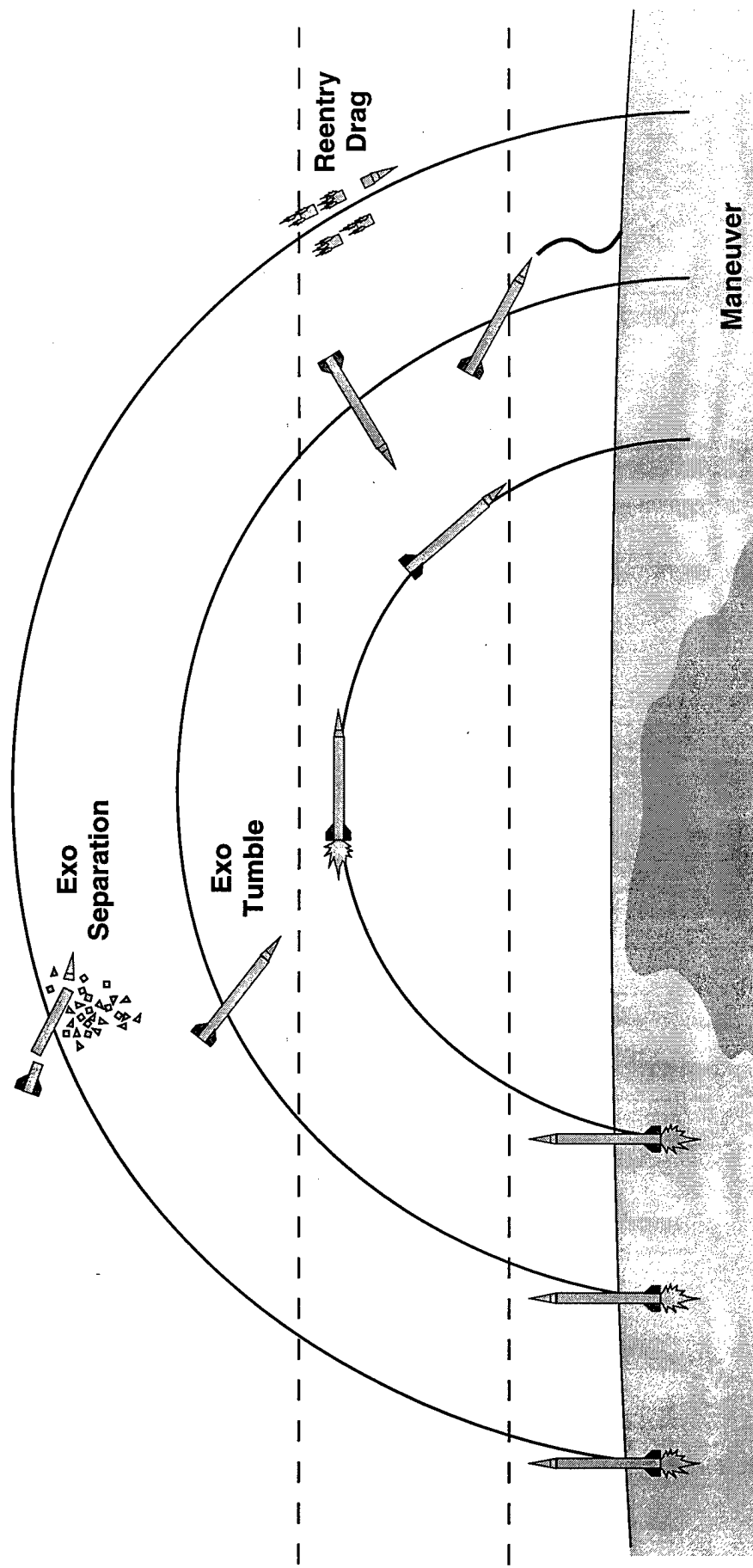


VALUE-ADDED BY REMOTE SENSOR TRACK DATA



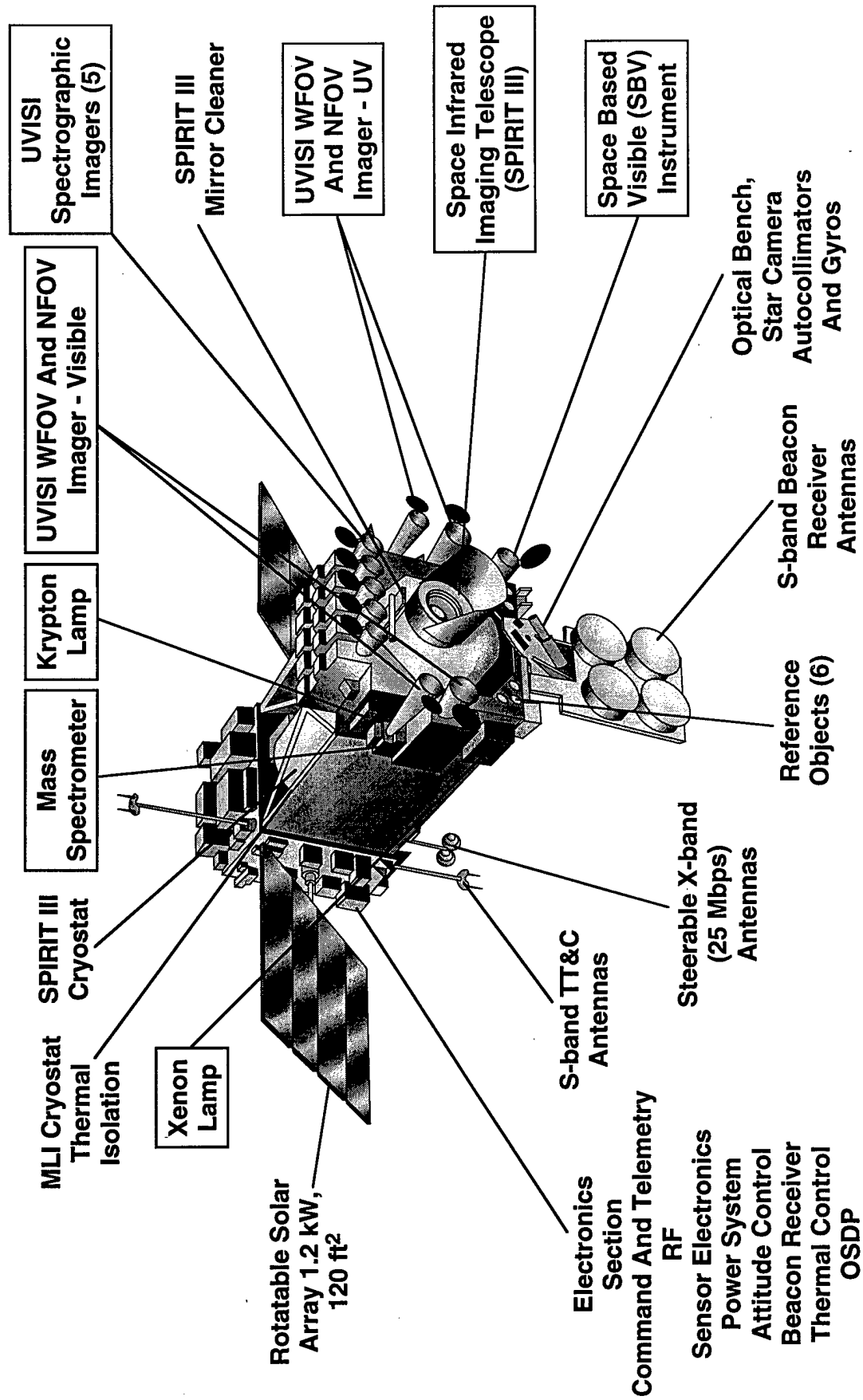


LIMITED INTERCEPTOR INVENTORIES WILL DRIVE USER TO SOPHISTICATED ENGAGEMENT STRATEGIES





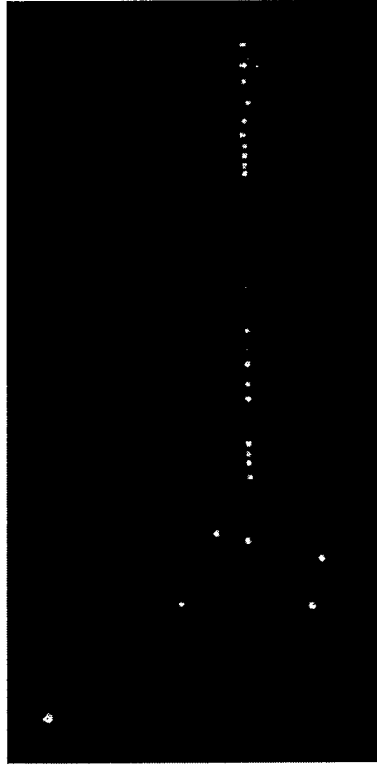
MSX SPACECRAFT CONFIGURATION



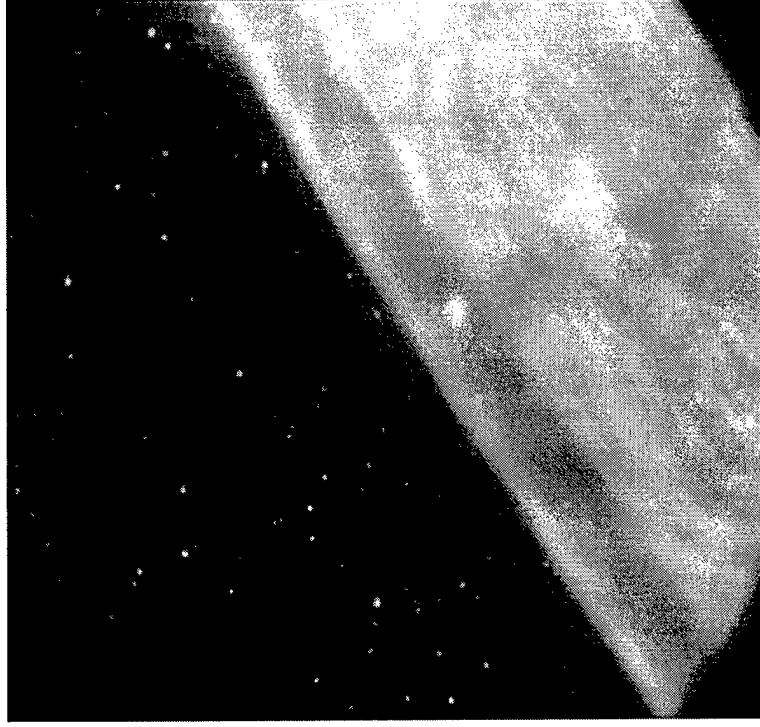


MIDCOURSE SPACE EXPERIMENT (MSX)

**MSX Dedicated Target
(MDT-2)**



**Earthlimb Backgrounds
And Reentry**



**Demonstrate Midcourse Functions And
Technologies And Measure Key Backgrounds**



SYSTEM EFFECTIVENESS

We Must Not
Engage Objects That Don't Need Killing

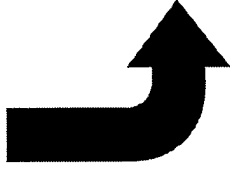
And

We Must
Kill Each Engaged Object



SUMMARY

“Fight Smart”



Sophisticated Engagement Strategies

- Threat Characterization
- Robust Discrimination
- Firing Policy Based On Family Of Systems Capabilities



TECHNOLOGY PROGRAM GOALS

Threats And Technology Do Not Stand Still, Therefore

- Support TMD And NMD With Component Technology Improvement

| <u>Increase</u> | And | <u>Decrease</u> |
|-----------------|-----|-----------------|
|-----------------|-----|-----------------|

- Range
- Lethality
- Accuracy
- Effectiveness
- Producibility

- Size
- Cost

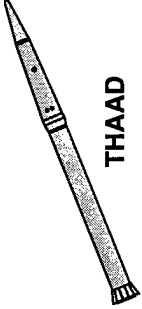
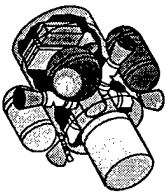
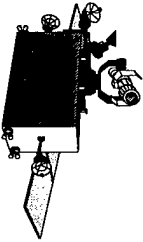
- Pursue Advanced Concepts For Future Responses To An Evolving Threat
 - New Kill Mechanisms
 - High Payoff (Boost Phase Intercept)



TECHNOLOGY PROGRAM

*Commonality / Interoperable
Open Systems*

Component

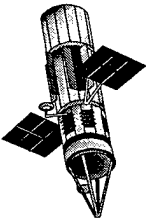



- Sensor Tracking / Discrimination
- Sensor Life
- Robust Design
- Interceptor Performance

Support To
Program

- PATRIOT • THAAD • GBR
- AEGIS • SMTS • GBI

Advanced Capability



- Directed Energy Boost Phase Intercept
- Airborne Kinetic Energy Boost Phase Intercept
- Sensor Performance

Create New
Options

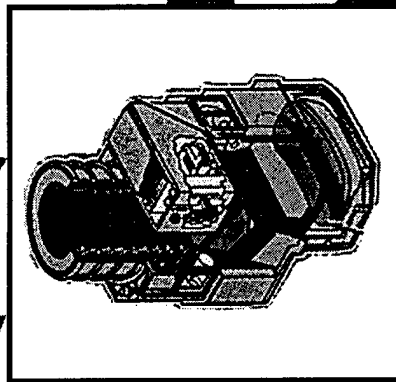
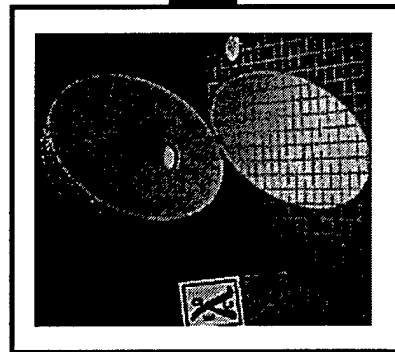
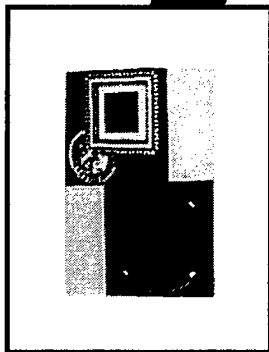
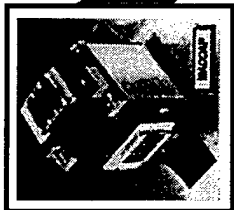
- Future
TMD And NMD



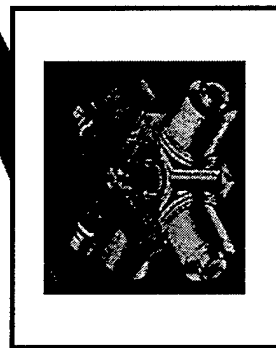
COMPONENT TECHNOLOGY UNDERPINS BMD

Signal Processors Optical Telescopes

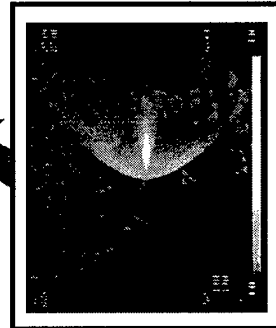
Focal Planes



Mirrors

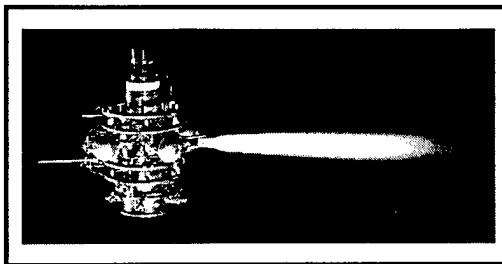


Cryocoolers

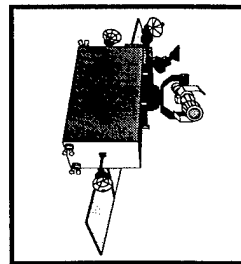


Optical Signatures

Kill Vehicle



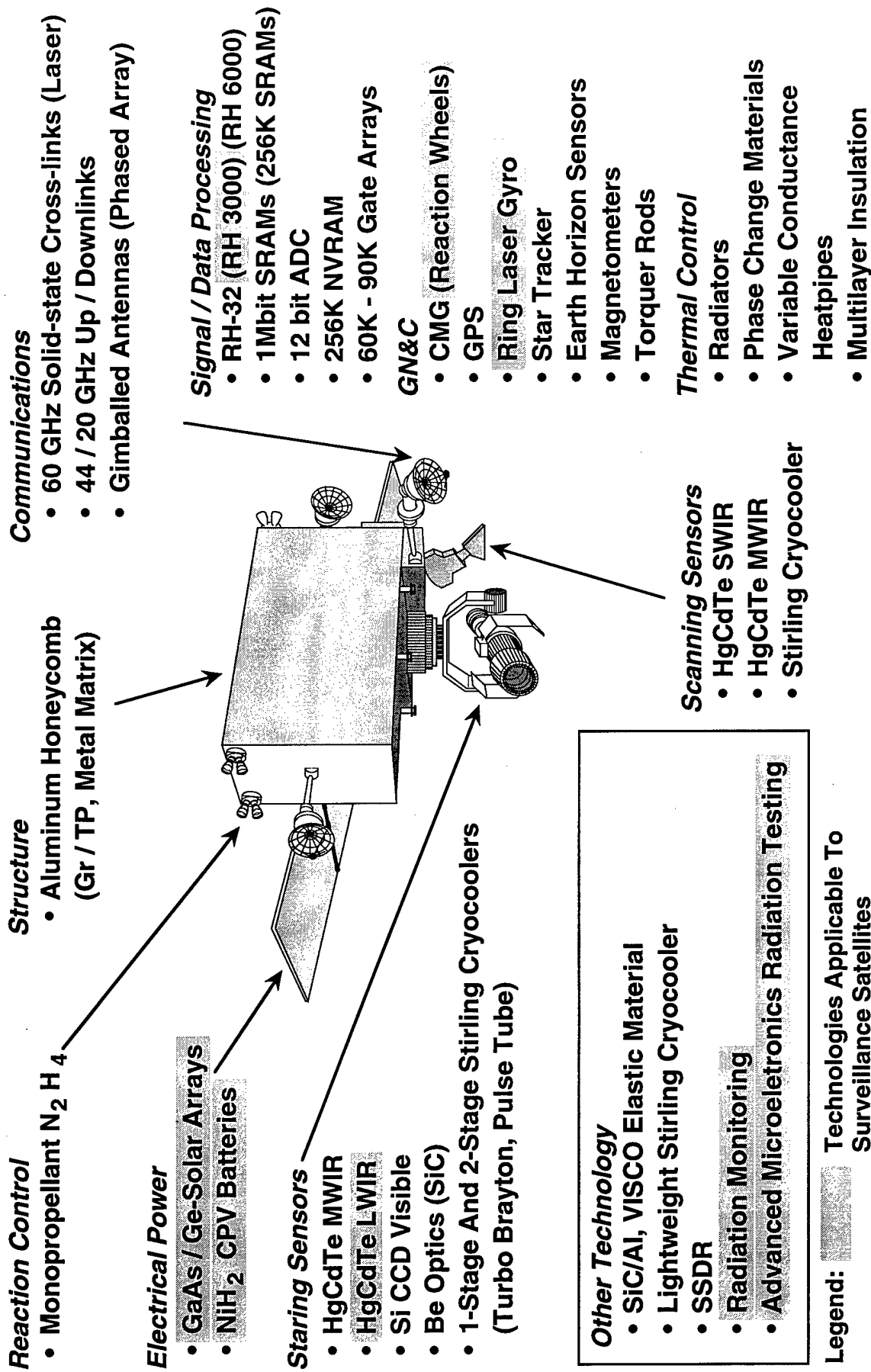
Surveillance
Platform



mj-48958A / 052595

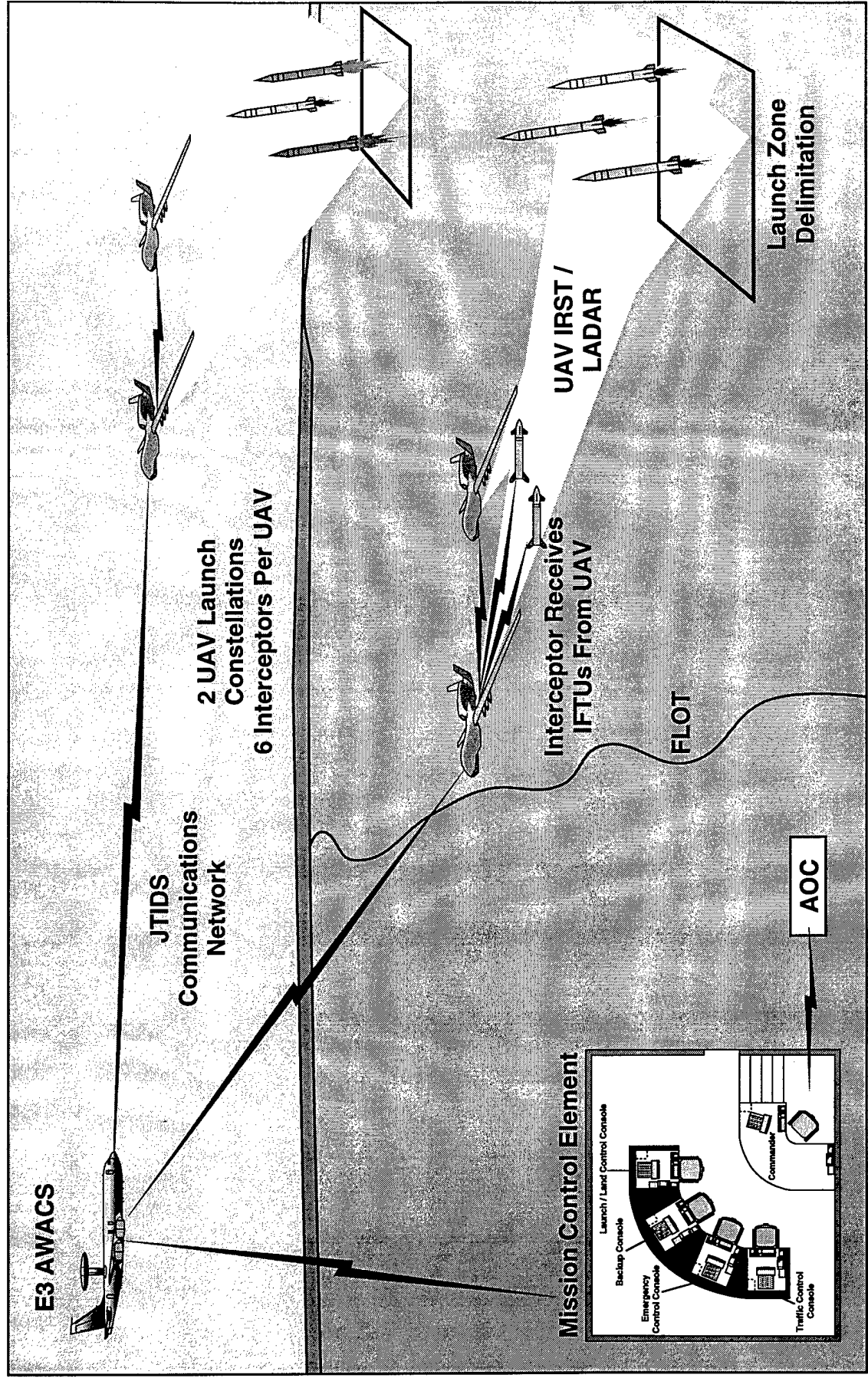


CLEMENTINE CONTRIBUTIONS TO SURVEILLANCE SATELLITES



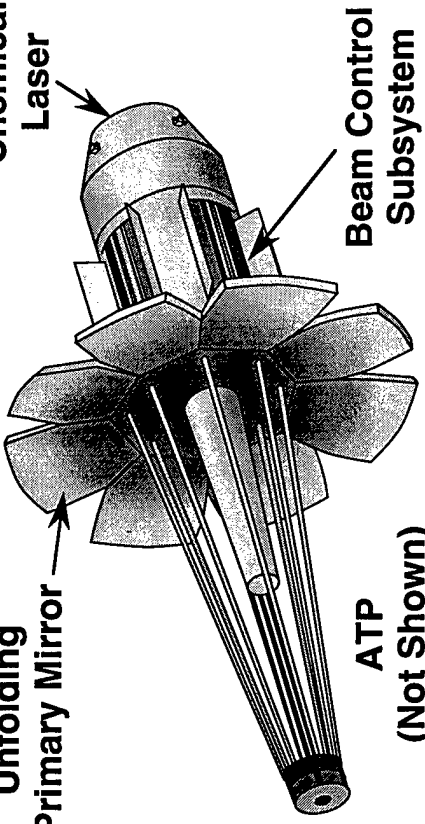


UAV BPI CONCEPT OVERVIEW





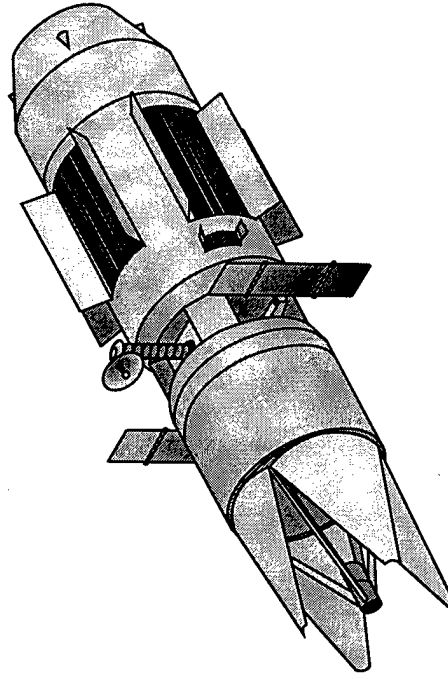
SPACE BASED LASER (SBL) SYSTEM

| | |
|--|---|
| <p>Notional Space Vehicle</p>  <p>Unfolding Primary Mirror</p> <p>Chemical Laser</p> <p>Beam Control Subsystem</p> <p>ATP (Not Shown)</p> | <p>Mission</p> <ul style="list-style-type: none"> • Continuous, Global Coverage, Boost Phase Intercept For NMD And TMD • Space Control • Other Futuristic Applications |
| <p>Operational System</p> <ul style="list-style-type: none"> • Policy / Treaty • Cost • Launch Vehicle (Size / Weight) • Integration Into NMD / TMD • Alternative System Concepts • Advanced Technology | <p>Development Issues</p> <p>Readiness Demonstrator (RD)</p> <ul style="list-style-type: none"> • POM Funding / Schedule • Traceability To Operational System • Spacecraft Integration • Maturity Of Technology (Risk) • Test Site |



SBL READINESS DEMONSTRATOR (SBLRD) TEST OBJECTIVES

- Perform A Realistic Demonstration Of An Integrated Laser Weapon Configuration In Space
 - Subscale But Representative Performance Levels
- Gain Experience Operating A High Energy Laser In Space
 - Collect Data Critical To Future EMD Design / Prototype
- Validate End-to-end Modeling
 - Laser Beam Generation, Control And Focusing At Long Range
- Perform Long-range ATP / FC Experiments
 - Low Power With Targets Of Opportunity
- Demonstrate Ability To Engage And Kill Thrusting Rocket Booster

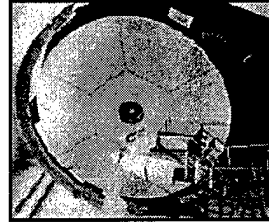


**Demonstrate The Technical Performance Of
An Integrated SBL Configuration In Space**

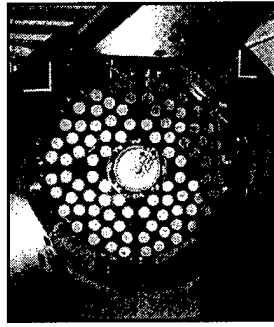


SPACE BASED LASER DEVELOPMENT CONCEPT

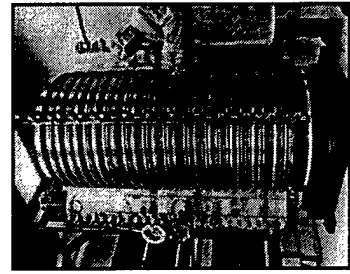
Demonstrated Technologies



Large Optics
(LAMP, 1989)



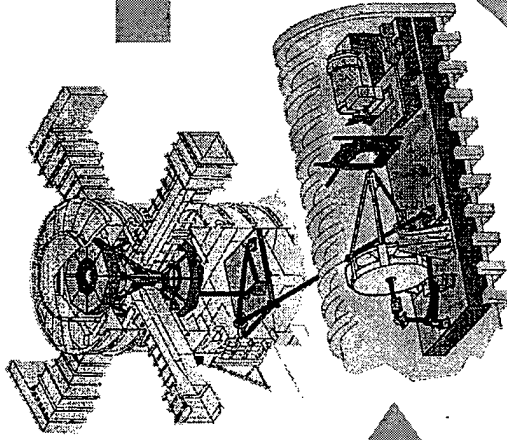
Beam Control
(LODE, 1987)



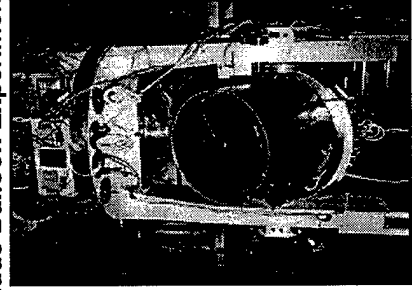
Laser
(Alpha, 1991)

Integration

Alpha LAMP Integration (ALI)
End-To-End Weapon Element Testing

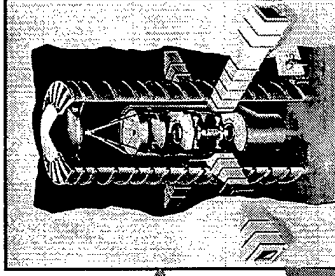


Acquisition Tracking, Pointing
And Fire Control
(High Altitude Balloon Experiment (HABE))

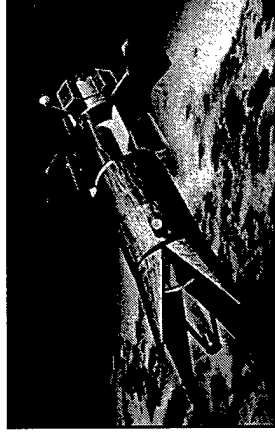


System-level Development

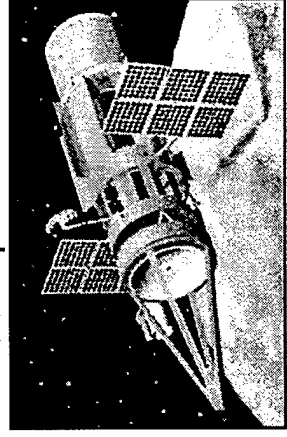
Integrated Ground Test



Readiness Demonstrator



Future Operational SBL

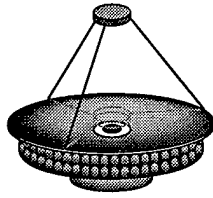


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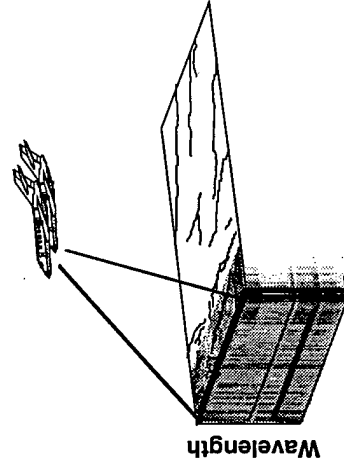
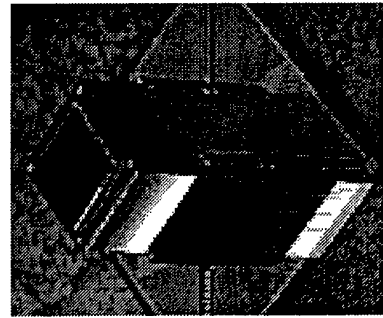
INNOVATIVE RESEARCH - HIGH RISK TECHNOLOGY FOR BMDO'S FUTURE

*Miniature Interceptors Counter
Dispersed Munitions*



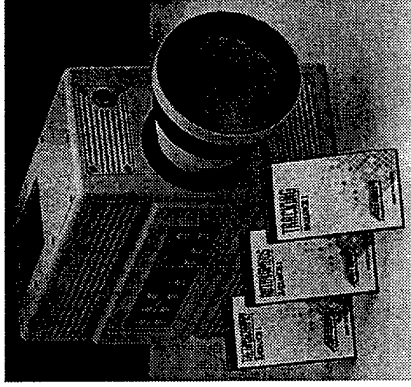
Supports Advanced Architecture Concepts

3-D Neural Network Processors



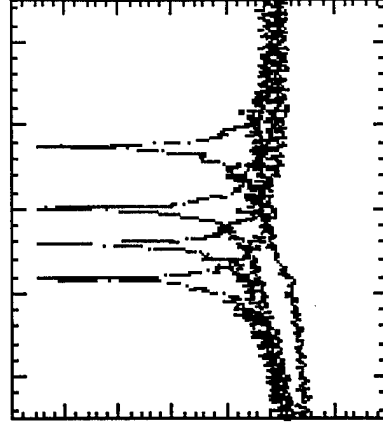
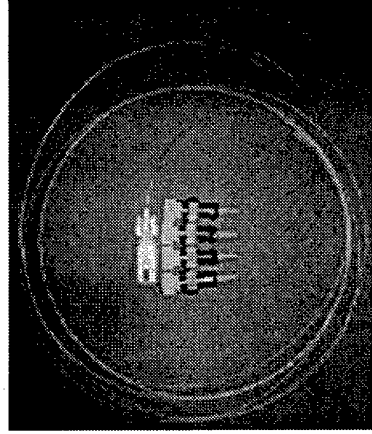
**Image Processing, Real-time Multisensor
And Hyperspectral Discrimination**

Quantum Well IR Sensor Camera



High Uniformity, Low Cost

High-speed Networks



Multiwavelength Lasers Increase Bandwidth

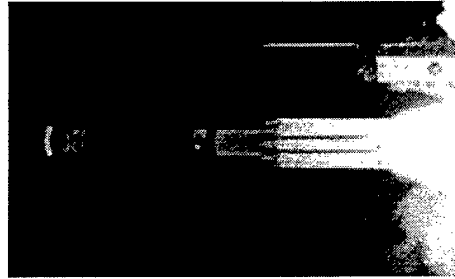


INNOVATIVE RESEARCH - HIGH RISK TECHNOLOGY FOR BMDO'S FUTURE (Cont'd)

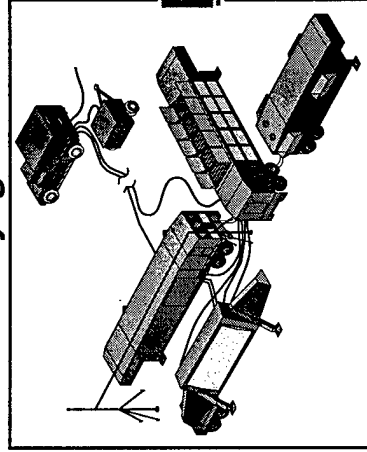
Sensor And Data Fusion Test Bed



Mobile Test Facility, UV, IR, And LADAR

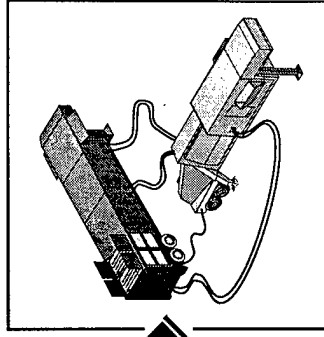


All Cryogenic Ground Based Radar



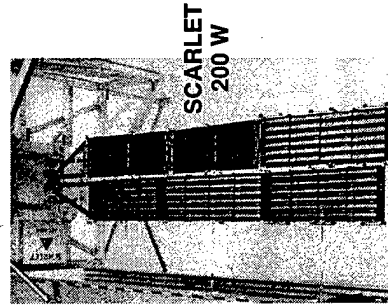
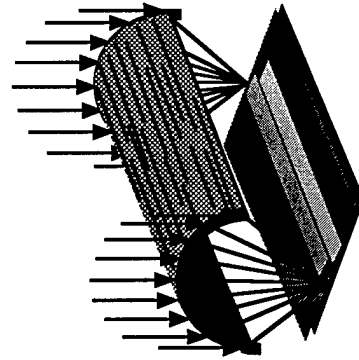
THAAD GBR (Typical)

Cryogenic Generator, Antenna Modules,
Power Conditioning



All Cryo-GBR Concept

Solar Concentrators



10 JUN 95 Goleta, CA
SCARLET Deployment Test

Cheaper, Lighter, More Efficient Space Power

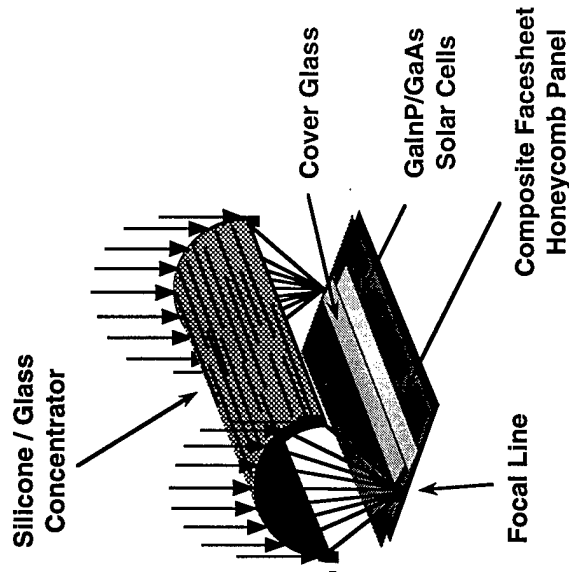
Other Topics

- High Energy Density Solid Propellants / Oxidizers
- Wide Band Gap (GaN) Microwave Power Amplifiers
- Laser Line-Of-Sight Communications
- Hyperspectral Imaging Techniques
- SBIR - Developing BMDO Required Commercial Products



SCARLET - HIGH PERFORMANCE SOLAR ARRAYS

- Solar Concentrator Arrays With Refractive Linear Element Technology
- Single Axis Inverted Through Fresnel Concentrator
- Performance Of Arrays Provides Many Operational Benefits
 - Efficiency = 23% (Versus 18% GaAs)
 - Recurring Cost < \$500 / W (Versus \$1,000 / W Si)
 - Van Allen Belt Radiation Tolerant (SBIRS, SBR, EOTV, etc.)
 - Array Specific Power > 50 W / kg (Versus 25 W / kg GaAs)

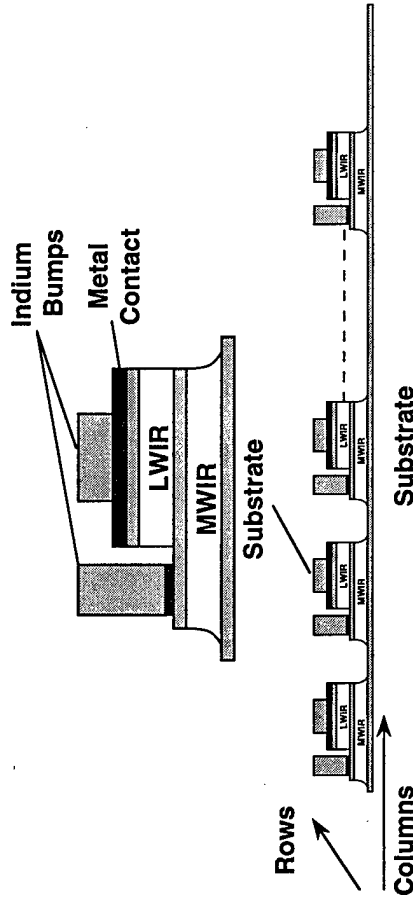


- SCARLET Will Be The Prime Power Source On NASA's / JPL's First New Millennium Deep Space Mission (DS-1)

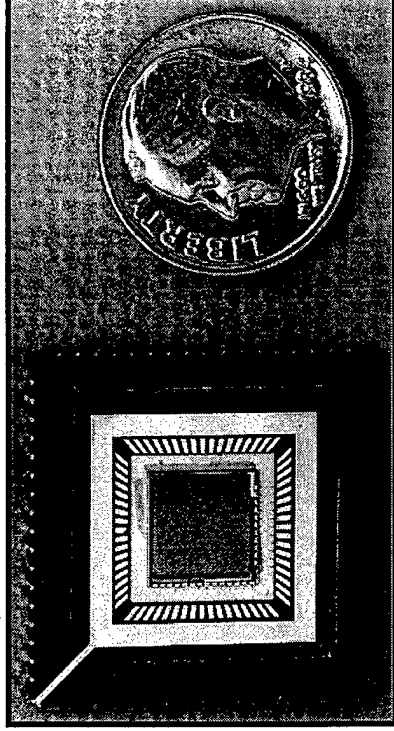


DUAL BAND QWIP FPAS

Dual Bump Two Color QWIP FPA



Multiple Quantum Well Staring Focal Plane Array Technology



Goals

- Perfectly Registered Dual Band Imagery
- Simultaneous Integration In Two LWIR Bands
- Reduced Real-time Signal Processing
- Reduced Cryogenic Size / Weight Power

Accomplishments

- Demonstrated Feasibility Of 256 x 256 Dual Band MWIR / LWIR FPA
- Sensitivity
 - MWIR $NE\Delta T < 0.05 \text{ K}$
 - LWIR $NE\Delta T < 0.05 \text{ K}$
- Corrected Responsivity Nonuniformity $< 1\%$



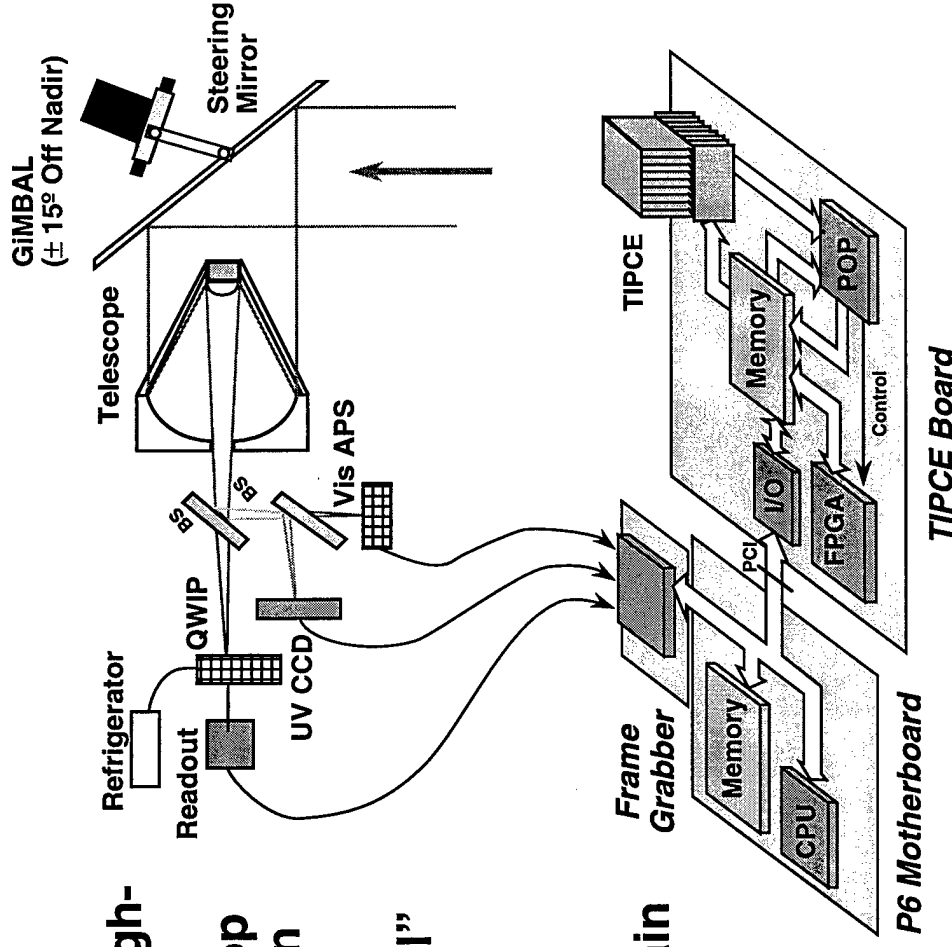
VIGILANTE PROVIDES PORTABLE, LOW-COST SENSOR/PROCESSING TEST BED

- **TIPCE Processor**

- Board With Local Bus, High-speed Digital Signal Processor And 3D Teraflop Inner Product/Convolution Engine (TIPCE)
- Mounted In "Conventional" Microprocessor System

- **Camera**

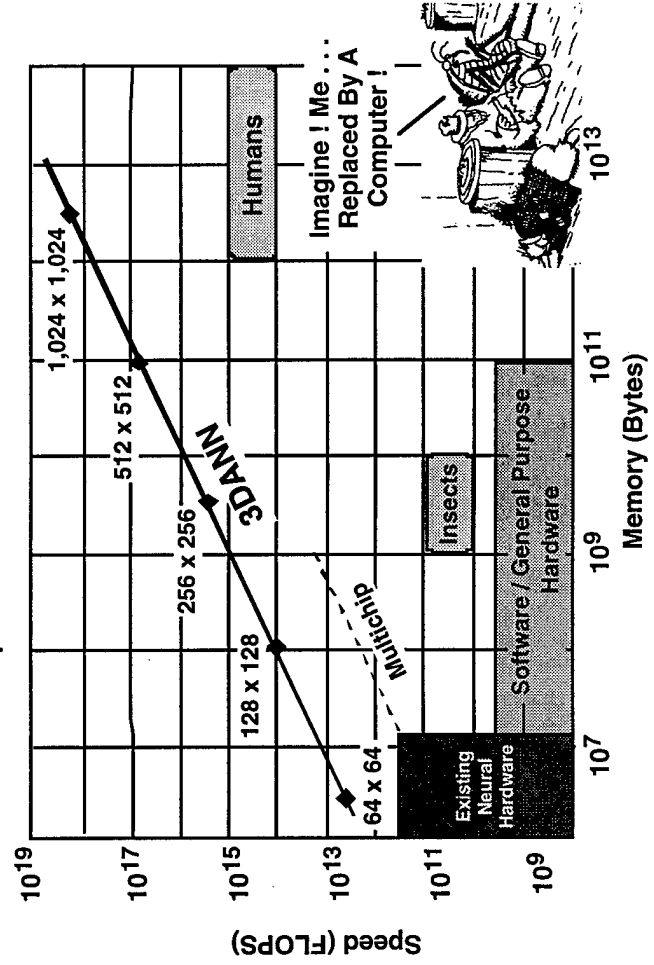
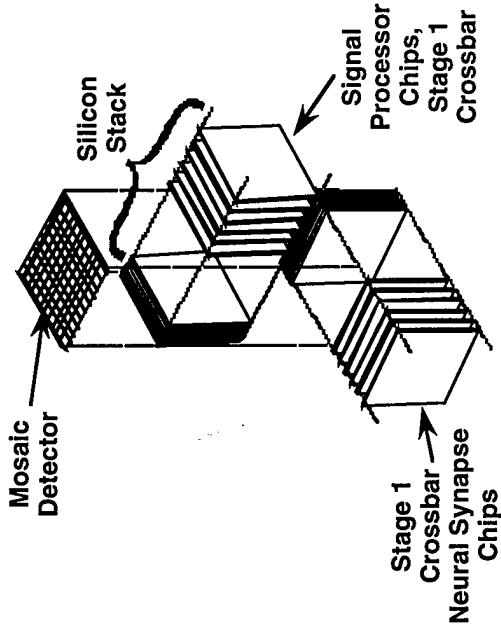
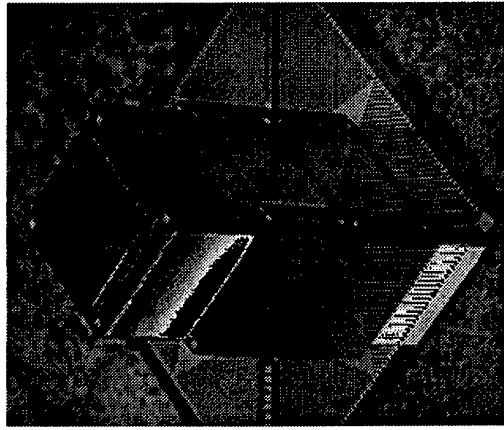
- Simple Modular Cassegrain With Gimballed Mirror
- LWIR: QWIP 9 μ m
- UV: δ -Doped CCD - UV
- Visible: APS





MODIFIED 3DANN CAN BE APPLIED TO SPEED UP VIGILANTE

Smaller Than 2
Stacked Sugar Cubes



• 3DANN: Three Dimensional Artificial Neural Network

- Compute Power Greater
Than Fast Supercomputer

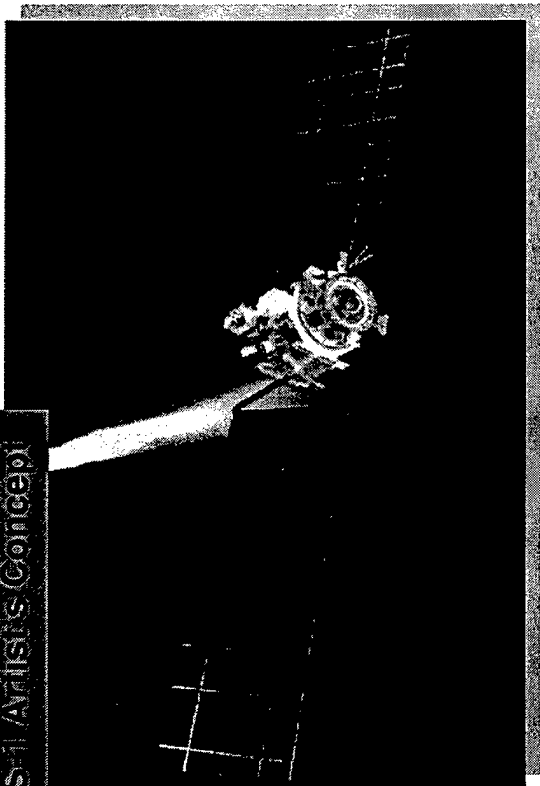
• Technical Leaders

- Carson - ISC, Thakoor,
Daud - JPL



SCARLET WING 1 ASSEMBLY (LATE APRIL 1997)

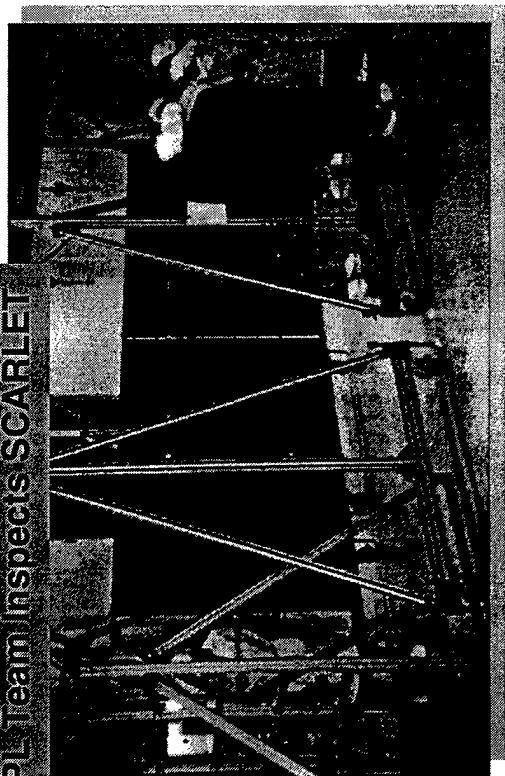
DS-1 Artist's Concept



DS-1 SCARLET Wing 1



JPL Team Inspects SCARLET





TECHNOLOGY PROGRAM PLANNING

